Comisión Nacional del Agua—National Weather Service

1999 Annual Report

# Transfer of the National Weather Service River Forecast System to Mexico

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[1]The Executive Summary and Project Recommendations are preceded by Spanish-language translations.

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## Resumen Ejecutivo

El Servicio Meteorológico Nacional de EE.UU (NWS) de la Administración Nacional Oceánica y Atmosférica de EE.UU (NOAA), en cooperación con la Comisión Nacional del Agua(CNA), está transfiriendo a México pronóstico de ríos de NWS y tecnologías asociadas. El proyecto comenzó en 1996, continuando hasta 1999. Ha sido respaldado por el Programa de modernización del Manejo del Agua (PROMMA), que intenta modernizar el manejo del agua en México. En 1996, ingenieros americanos y mexicanos comenzaron la cooperación para implementar tecnología de pronóstico de ríos en dos cuencas de ríos muy importantes en el noroeste de México, el Río Fuerte y el Río Yaqui. En 1999, ingenieros de ambos países cooperaron para implementar esa tecnología en otras dos cuencas de ríos, en parte del Río Bravo en el norte, y el Río Pánuco en el noreste de México. Debido a que gran parte del desarrollo de esta tecnología en 1999 se enfocó en las cuencas de ríos fronterizos con los EE.UU, el planeamiento de reuniones sobre obligaciones relaciondas con manejo de agua bajo tratados bilaterales jugó un rol muy importante en las actividades de 1999.

Los datos y la información son aspectos fundamentales para el pronóstico y monitoreo de ríos. En 1999, la CNA y el NWS cooperaron en el desarrollo de tecnologías para reforzar el flujo de datos regionales a los sistemas de pronóstico, por medio de comunicaciones de datos y tecnologías de bases de datos modernas. Estos tipos de tecnologías se desarrollaron primero con el objetivo de transferir datos e información entre la Ciudad de México y la CNA de la Región Noroeste, basada en Hermosilla, Sonora. La CNA con el NWS están cooperando también en la integración de tecnologías GIS ( *del inglés*- Geographic Information System- Sistema de Información Geográfica) con tecnologías de predicción de inundaciones, para proveer de información más precisa y apropiada a los funcionarios a cargo del manejo de emergencias, y de esa forma ayudar a mitigar la pérdida de vidas humanas o propiedad. Ambas instituciones están también cooperando en la evaluación de técnicas para la estimación de precipitaciones de imágenes de satélite, usando tecnologías mexicanas y americanas. Finalmente, el proyecto continúa su respaldo para la traducción de inglés al español de la documentación clave, que ahora se encuentra en el Internet.

## Executive Summary

The National Weather Service (NWS) of the National Oceanic and Atmospheric Administration (NOAA), in cooperation with the Comisión Nacional del Agua (CNA), is transferring NWS river forecasting and associated technologies to Mexico. The project began in 1996 and continued through 1999. It is supported by the Programa de Modernización del Manejo del Agua (PROMMA), which is intended to modernize water management in Mexico. Beginning in 1996, Mexican and US engineers cooperated on implementing river forecasting technology in two major

river basins in northwestern Mexico, the Río Fuerte and the Río Yaqui. In 1999, engineers from both countries cooperated on implementing the technology in two additional river basins, the Middle Río Bravo in the north and the Río Pánuco in the northeast of Mexico. Because much of the development of these technologies in1999 were focused on the basins on the border with the US, planning meetings about water-related obligations under bilateral treaties played a significant role in 1999 activities.

Data and information are important aspects of river forecasting and monitoring. In 1999 CNA and NWS cooperated on developing technologies to strengthen the flow of regional data to the forecast systems, via modern data-communications and data-base technologies. These types of technologies were developed first to strengthen the transfer of data and information between Mexico City and the CNA Noroeste Region, which is headquartered in Hermosilla, Sonora. The CNA and NWS also are cooperating on integrating Geographic Information System (GIS) technologies with flood-forecasting technologies to provide emergency management officials with more timely and accurate information to mitigate the loss of life and property. Both organizations also are cooperating on evaluating techniques for estimating precipitation from satellite imagery using Mexican and US technologies. Finally, the project continues to support the translation of key documentation from English to Spanish, which now is available on the Internet.

**Introduction**

This report documents 1999 activities that the NWS undertook to support PROMMA, which is funded by the Mexican government and the World Bank. The key components of NWS support to CNA are the implementation of the NWS River Forecast System (NWSRFS) in selected river basins in Mexico, and establishment of Regional River Forecast Centers (RRFC's). The latter activity is consistent with CNA policy to decentralize water management in Mexico and strengthen water management in 13 CNA regions.

CNA and the NWS agreed in principle to a multi-year plan, in which project activities are defined by annual letters of agreement on a calendar-year basis. The first agreement was completed in November 1996 and provided for the procurement of workstations and other activities to initiate the project. The second and third agreements were completed in February 1997, and January 1998, respectively. The 1999 agreement was dated January 4, 1999.

During 1999, several Mexican, United States, and international organizations participated in the project. The NWS principal partner was the Gerencia de Aguas Superficiales e Ingeniería de Ríos (GASIR). GASIR is responsible for monitoring surface-water resources in Mexico and the management of major rivers and reservoirs. The Mexican meteorological service, Gerencia de Servicio Meteorológico Nacional (GSMN) is a second NWS partner. Both organizations reside in the Subdirección General Téchnico (SGT) of CNA. The NWS and GSMN have cooperated on meteorological issues for more than 50 years and continue to cooperate on meteorological issues, in addition to hydrological issues under PROMMA.

An important focus of 1999 activities concerned implementing river forecasting technology for

the Middle Río Bravo basin between the Presa de la Amistad and the Presa Falcon. The basin resides in parts of the States of Coahuila, Nuevo Leon, and Tamaulipas. Because this activity concerned forecasting and management of a boundary river, the US International Boundary and Water Commission (IBWC) and Mexican Comisión Internacional de Límites y Aguas (CILA) participated in the project. One CILA engineer and several CNA engineers participated in implementing the forecast system, known as the Río Bravo Sistema de Pronóstico en Ríos de la CNA (SPRCNA). As part of their training and cooperative development, the CILA/CNA engineers visited the NWS West Gulf River Forecast Center (WGRFC), which is responsible for river forecasting the Rio Grande basin. In support of this activity, the NWS organized a study tour in July 1999 to the United States for CNA and CILA/IBWC representatives, who visited three vendors of automated hydrometeorological data-collection systems and key Federal water and weather agencies.

Throughout the year, NWS staff coordinated activities with consultants of the World Meteorological Organization (WMO), who are assisting GASIR redesign and plan automation of hydrometeorological data-collection networks in 14 major river basins in Mexico. In 1999, WMO assisted GASIR manage the installation of an automated data-collection network in the Río Bravo basin.

This report consists of an Executive Summary, Introduction, 1999 Project Activities, 1999 Budget, and Recommendations. These recommendations are based upon lessons learned from implementing the NWSRFS in the United States and experience with this project. The recommendations are followed by References and Acronyms used in the report. Finally, because language is an important issue in this project, the Executive Summary and Project Recommendations are provided in Spanish and English.

**1999 Project Activities**

The 1999 agreement identified seven tasks that the NWS undertook with the cooperation of GASIR and other CNA organizations. These tasks are listed below and task summaries follow.

| Task Number | Task Title |
|---|---|
| 99.1 | Río Bravo SPRCNA Implementation |
| 99.2 | Río Pánuco SPRCNA Implementation, phase 1 |
| 99.3 | Implement Regional River Forecast Center |
| 99.4 | Consultant, SPRCNA |
| 99.5 | Project Management |
| 99.6 | Satellite Precipitation Estimation |
| 99.7 | NWSRFS Documentation Translation |

Task 99.1 Río Bravo Implementation

Many project activities concerned the Middle Río Bravo river basin and sub basins, which lie in the border area between Mexico and the US (see Figure 1.). Early in the year, NWS and CNA briefed the CNA Río Bravo Regional staff and CILA/IBWC[2] representatives about NWS flood forecasting technology and the CNA-NWS program. On March 29, NWS and CNA representatives visited CNA Río Bravo Regional headquarters in Monterrey, Nuevo Leon. Regional Director, Ing. Abelardo Amaya Enderle and Regional Technical Director, Ing. Juan Emilio Garcia Cardenas hosted the visit. Three CILA representatives also participated in the NWS visit. On March 30, the NWS and CNA representatives, accompanied by Río Bravo regional representatives, visited CILA in Ciudad Juarez, Chihuahua. The visit was co-hosted by CILA Director of Operations Ing. Gilberto Elizaldo H. and IBWC Principal Engineer Carlos Marin. Also, in attendance were several IBWC and CILA staff members, and a senior hydrologist from the NWS WGRFC in Fort Worth, Texas. During both meetings, the NWS-GASIR team provided a brief overview of the CNA-NWS project and the reasons for the visit, which were to inform the host organizations about the Río Bravo forecast system, solicit their assistance, learn about border water-management issues, understand how the NWSRFS could serve border interests, and strengthen coordination of the CNA-NWS project with CILA and IBWC.

Concurrently, Riverside Technology Inc. (RTi), a technical-support contractor to NWS, undertook extensive analysis of hydrologic data for the Middle Río Bravo basin in preparation for implementing the SPRCNA (Riverside Technology, Inc., 2000a). This included completing precipitation and evapotranspiration analysis, isohyetal map development, and developing Mean Areal Precipitation (MAP) time series and water balance-analysis. Additionally, RTi began to prepare channel-routing models and unit-hydrograph parameters in anticipation of calibrating rainfall-runoff models.

During April 26 - May 14, six engineers from several organizations received an overview of river forecasting technology and began intensive data-collection training and cooperative development in Fort Collins, Colorado. The engineers and their organizations were:

Ing. David Negrete Arroyo . . . . . CILA
Ing. Tirso Ubaldo Valdez Molina . . . . . CNA Río Bravo Region
Ing. Jose Manuel de Jesus Calderon Rodriguez . . . . . CNA Noroeste Region
Ing. Luis Antonio Cabrera . . . . . GASIR
Ing. Marco Salas . . . . . Instituto Mexicano de Technología del Agua (IMTA)
Ing. Francisco Gomez . . . . . IMTA

[2]The NWS met with and briefed US State Department officials on the CNA-NWS program in February, 1999.

The engineers returned to RTi for additional training and cooperative development from July 5 - 23 on data analysis and model calibration, and from October 4-22 for system implementation and operation. Throughout much of the year, RTi engineers visited Mexico City frequently to assist the engineers continue their participation in system development.

On May 11, an NWS representative participated in a meeting at the CNA Río Bravo Regional office in Monterrey with CNA and contractor staff, and a WMO consultant on the design and implementation of a 44-station real-time Geostationary Operational Environmental Satellite (GOES) Data Collection Platform (DCP) network in the Río Bravo basin. The network includes two Direct Readout Ground Stations (DRGS) that were being installed in Monterrey and Ciudad Juarez.

As a result of the May 11 meeting, the NWS organized a study tour for CNA and CILA/IBWC representatives to familiarize them with manual and automated hydrometeorological data-collection instrumentation used in the United States. During the July 18-24, 1999 tour, the team visited the US Geological Survey (USGS) Arizona District in Tucson, Arizona, the USGS Hydrologic Instrumentation Facility (HIF) at the National Aeronautics and Space Administration (NASA) Stennis Space Center, Mississippi, USGS National Headquarters in Reston, Virginia, and NWS National Headquarters in Silver Spring, Maryland. They also visited Hydrolynx and Handar Inc. in California, and Sutron, Inc. in Virginia; all three are manufacturers


**Figure 1** Middle Río Bravo basin and sub basins

of automated hydrometeorological equipment. During these visits, the participants were briefed on alert technology, hydrometeorological data-collection equipment, DCP's, training, and test, procurement, repair, and maintenance of hydrometeorological equipment.

At a meeting at the GASIR office in Mexico City, an RTI/NWS team delivered the Middle Río Bravo SPRCNA on December 15, 1999. At that time, GASIR engineers who are responsible for daily operation of the Ríos Fuerte and Yaqui SPRCNA, were instructed in the operation of the Middle Rio Bravo SPRCNA. NWS, RTi, and CNA engineers also made presentations on numerous aspects of the 1999 CNA-NWS program. Representatives of CILA/IBWC and CNA Noroeste, Pacifico Norte, Río Bravo, and Golfo Norte Regions attended the meeting.

Task 99.2 Río Pánuco Implementation, Phase 1

As shown in Figure 2, the Río Pánuco is a complex and large basin in eastern Mexico. It includes high-altitude mountainous regions in the upper part of the basin and very flat meandering river systems in the lower part. There is a long history of devastating floods in the basin, and especially near Tampico, Tamaulipas.

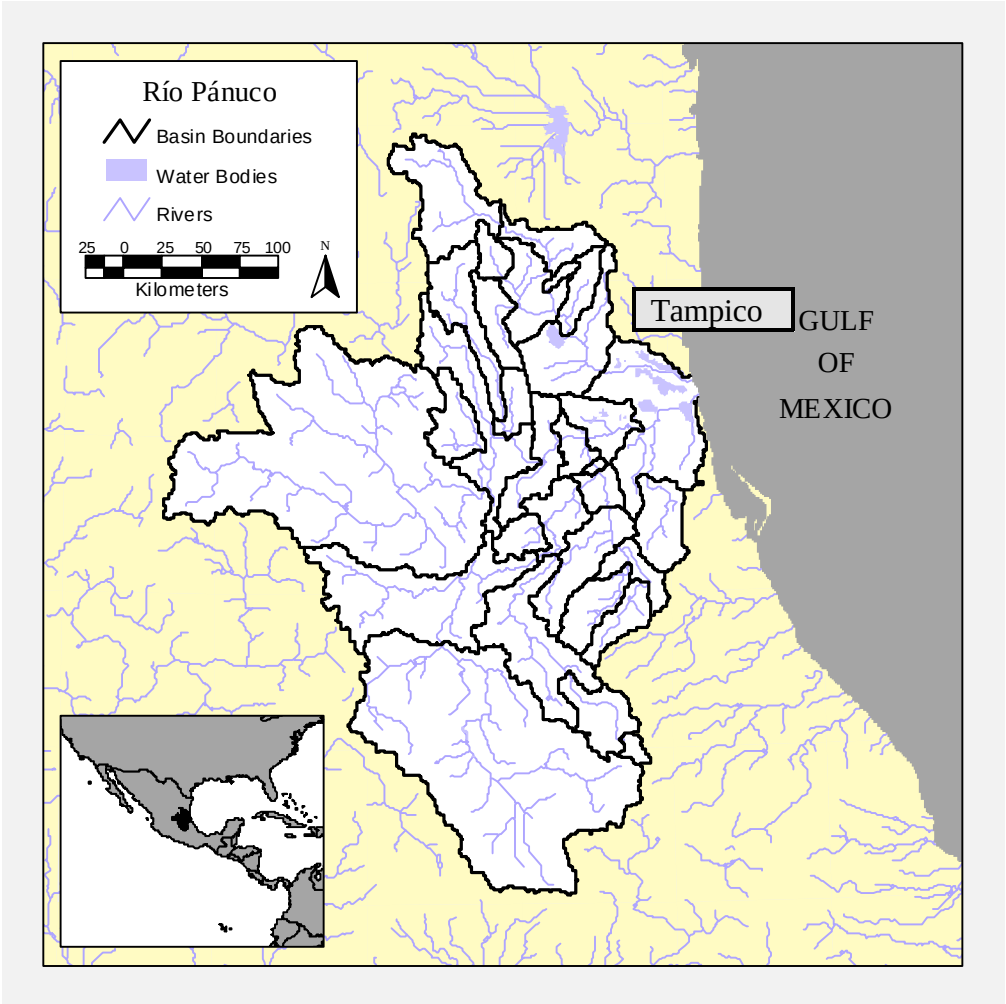


**Figure 2** Río Pánuco basin and sub basins

There were three goals to implementing phase 1 of the Río Pánuco SPRCNA. The first was for GASIR engineers to undertake data collection and system implementation in 1999

and prepare for data analysis and calibration in phase 2 in 2000. The second goal was for the NWS to evaluate whether the NWS dynamic flood model (FLDWAV) would be appropriate to model the hydraulic processes in the basin. The third goal was for the NWS National Operational Hydrologic Remote Sensing Center (NOHRSC) in Chanhassan, Minnesota to prepare a framework to integrate Tampico flood forecasts from the completed SPRCNA and represent the forecasted flood in a Geographic Information System (GIS) (NWS, 1999). In Phase 2, the river forecast and GIS systems will be implemented and integrated. Throughout the year, RTi representatives provided guidance to GASIR engineers as they conducted Río Pánuco data analysis and system implementation (Riverside Technology, 2000c). This guidance was in the form of weekly telephone conference calls between Fort Collins and Mexico City, periodic visits by RTi to Mexico City, and review of progress made by the GASIR engineers throughout the year. On December 15, RTi representatives made a presentation of the process of implementing the NWSRFS in the Río Pánuco and GASIR engineers presented an overview of the work that they accomplished throughout the year, which was to collect historical hydrometeorological data and initialize a subset of the forecast system for the complete Rio Pánuco basin

In early June, NWS representatives visited Tampico and surrounding areas, and met with CNA Golfo Norte Regional Technical Director Enrique Lopez Peres and other CNA Regional and State staff. GASIR Mexico City representatives Ing. Luis Espinosa and Ing. Vicente Castañeda Peña joined the meeting. At the meeting, participants provided an overview of the CNA-NWS project, hydrologic forecasting, and the data-exchange program that the NWS is developing for CNA, which is discussed under Task 99.3 below. Regional Technical Director Lopez provided an extensive overview of the Pánuco basin and major floods that have occurred in the basin. Ing. Espinosa briefed the group on CNA's experience with hydraulic modeling of the lower reaches of the basin. Subsequent to the meeting, several CNA staff accompanied the NWS representatives on a field trip to hydrologic stations and flood-prone areas in the vicinity of Tampico. During the visit, the CNA provided the NWS with river cross-sectional data, maps of data collection stations, and documentation on dynamic routing models used by GASIR. As a result of the information gained from the visit, RTi provided a report (Riverside Technology, Inc 1999a) to the NWS that found that the NWS FLDWAV model is appropriate for modeling the lower parts of the basin in 2000.

Throughout the year, staff of the NOHRSC prepared the framework of a GIS-based system that would represent visually, probabilistic flood potential from Río Pánuco flooding in the Tampico area. The visual representation would be combined with data bases on infrastructure such as schools, hospitals, evacuation routes, sources of industrial contamination, sites of hydrologic stations, and population shelters. The data bases, combined with the probabilistic flood forecast, would provide sufficient advance warning and information to emergency managers to assist them minimize life and property loss. Using hypothetical infrastructure data bases and available, low-precision urban maps and Digital Elevation Model (DEM) data, the NOHRSC prepared the system for a demonstration in 2000. An example of a GIS-based probabilistic flood inundation map for Tampico is shown in Figure 3.

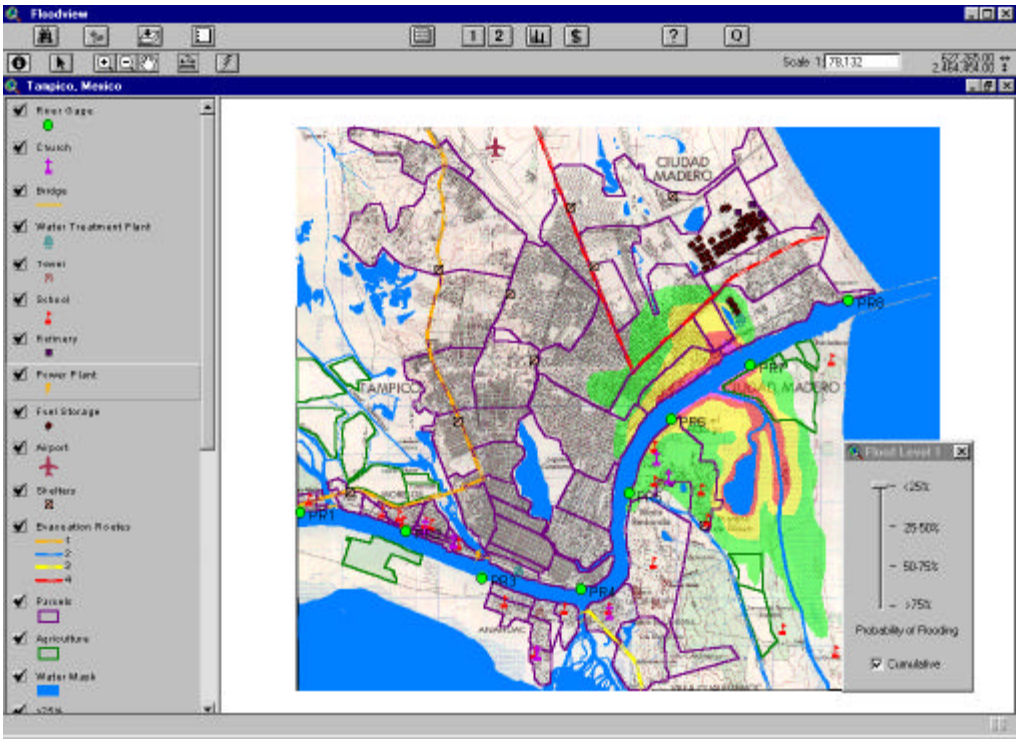


**Figure 3.** GIS display of hypothetical flood probability in Tampico, Tamaulipas.

The NOHRSC provided a briefing on the system in Mexico City on December 14 and 15. The first presentation was part of a joint seminar on information, river forecasting, and monitoring networks that was conducted by PROMMA with the assistance of the WMO and the NWS. The seminar was entitled *Seminario sobre Sistemas de Infromación, Sistema de Pronóstico de Ríos, Redes de Monitoreo Hidrológico y Meteorología* ( Seminar on Information Systems, River Forecast Systems, and Hydrologic and Meteorologic Monitoring Networks) and was attended by approximately 100 CNA Regional and Headquarter staff. The second presentation was given at delivery of the Río Bravo SPRCNA, which is discussed in Task 99.1. Finally, on December 16, NOHRSC staff met with CNA GIS experts and Mexican private-sector representatives to discuss availability of DEM and infrastructure data. It was apparent that sufficient high quality DEM and infrastructure data will be available for the Tampico area in 2000 and an implementation of the GIS representations of flood forecasts will be possible.

Task 99.3 Implement Regional River Forecast Center

The initial activities under this task were to purchase a Hewlett-Packard workstation and plan data base applications to support exchange of data between the Noroeste RRFC (NRRFC) in Hermosillo and Mexico City. GASIR also provided the NWS with copies of all of the reports that GASIR prepares for national water-management meetings that senior CNA staff conduct weekly. The reports provided templates for the initial reports that will be prepared from the new GASIR data base.

During April 19-20, NWS and GASIR representatives met in Hermosillo, Sonora, with CNA Noroeste Regional Director Miguel Angel Jurado, Regional Technical Director Martin Rodriguez, and other CNA officials. The objectives of the visit were to brief regional staff on the 1999 program to develop the NRRFC in Hermosillo, define the need for exchanging data and information between the Noroeste Region and Mexico City, discuss preliminary conceptual design of the data-exchange system, review training of regional staff, and meet with representatives of Comisión Federal de Electricidad (CFE) and local irrigation districts as potential recipients of NRRFC forecasts and other products.

Throughout the year, RTi developed Internet-based software designed to facilitate the exchange of information between Hermosillo and Mexico City (Riverside Technology, Inc., 2000b). In July, a hydrometeorological data systems needs assessment report was prepared by RTi and subsequently provided to GASIR and the PROMMA office by the NWS (Riverside Technology, Inc., 1999b) . By early August, initial web-based software had been prepared and RTi made initial software installations at GASIR offices at 192 Av. Observatorio in Mexico City. Subsequently in the December, NWS representatives visited Hermosillo to administer the workstation, and integrate it into an Internet Protocol (IP) network with a personal computer that has limited dial-up Internet access. During this installation, the Río Fuerte and Río Yaqui SPRCNA's also were installed on the Yaqui workstation.

In December, the first phase of the data base and data transfer system were delivered to CNA. A description of the system was presented at the December 14 *Seminario sobre Sistemas de Infromación, Sistema de Pronóstico de Ríos, Redes de Monitoreo Hidrológico y Meteorología*, and presented and demonstrated at the December 15 delivery of the Middle Río Bravo SPRCNA. As shown schematically in Figure 4, each morning Noroeste Regional staff will manually enter daily hydrometeorological data from a Noroeste Regional network into a central Internet web page that is operated on a CNA workstation in Mexico City. After the data are entered and have been reviewed by Noroeste staff, they are posted to the Internet GASIR-Data Base (IG-DB). Once in the data base, the data will be sent as Standard Hydrologic Exchange Format (SHEF) messages to river forecast system data bases in Mexico City and the Noroeste Region. Forecast products from central and regional forecast systems also can be transferred to and stored in the IG-DB. Concurrently, the IG-DB will be used to prepare reports for CNA officials in Mexico City and Hermosillo; at the discretion of CNA, selected reports also can be made available to external users or the public. Once the system is operational in 2000, it can be made available for data entry and report generation by all 13 CNA regions. Although not shown in Figure 4, CNA and the NWS have agreed that the IG-DB will be used to support the (a) exchange of hydrometeorological data and information between NWS RFC's and other sources in the United States, and counterpart organizations in Mexico, and (b) reception of GOES-telemetered data from CNA hydrometerological networks.

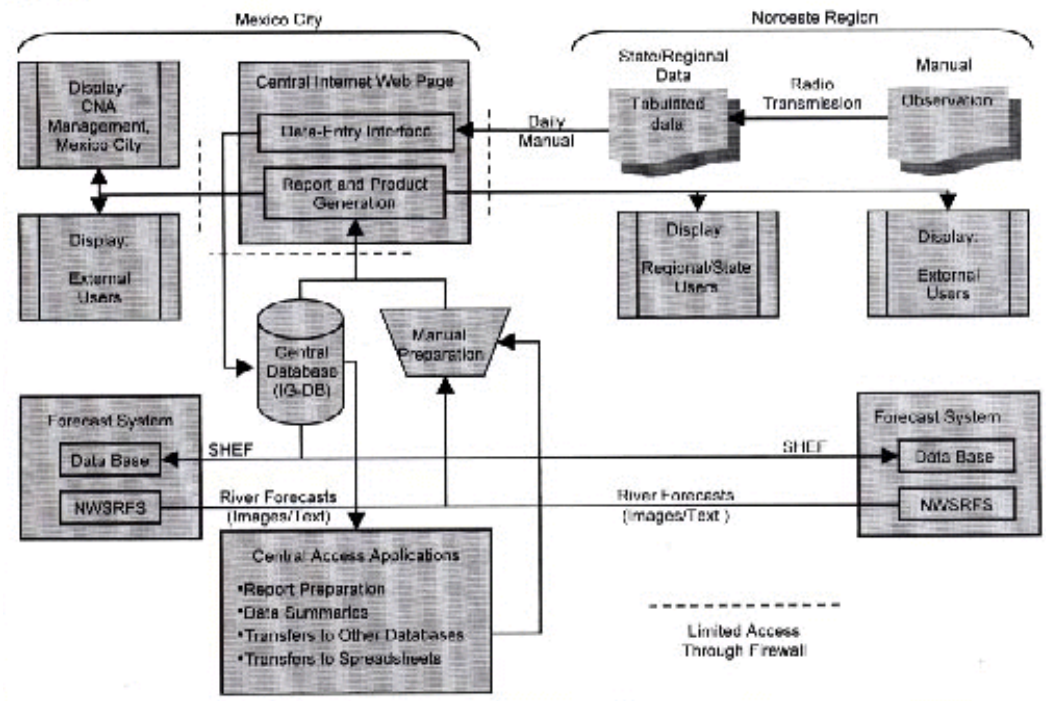


**Figure 4.** Data base applications, and data and information exchange between Mexico City and the Noroeste Region.

Late in the year—and in anticipation of establishing the Río Bravo RFC (RBRFC) in 2000—CNA and NWS initiated the procurement of four additional workstations. After the NWSRFS and data base software are loaded on the workstations in Silver Spring, Maryland, the workstations will be shipped to Mexico to add enough redundancy to support data exchange and forecasting operations in Mexico City and Hermosillo, and establish a similar capability in Monterrey. Towards that goal, one of the four workstations will be transferred to Mexico City, where currently there are two workstations, so that there will be three operational workstations. One will be outside a firewall to host the Central Internet Web Page and two will be inside the firewall. Of the two inside the firewall, one will be used as a database server, with both workstations configured to back up the other. The second workstation will be transferred to Hermosillo, so that the NWRFC will have a backup configuration for redundant system operation. Eventually, two workstations will be transferred to Monterrey, so that the RBRFC also will have a backup configuration.

Task 99.4 Consultant, SPRCNA

This task was dedicated to supporting GASIR operations of the Río Fuerte and Río Yaqui SPRCNA's. Towards that goal, RTi and the NWS continued to provide assistance to GASIR engineers throughout the year, update the forecast system to solve operational problems, and administer the workstations. Additional precipitation stations in the Río Fuerte and Río Yaqui basins were identified and analyses performed in anticipation of data from these stations being incorporated into the definition of the forecast system.

Task 99.5 Project Management

Throughout the year, project staff coordinated project activities with numerous organizations in the United States and Mexico, participated in travel to Mexico City, Hermosillo, Tampico, Monterrey, and Ciudad Juarez in Mexico, and Sacramento, Rancho Cordova, Tucson, Stennis Space Center, Fort Worth, Fort Collins, and Washington, D.C. in the United States. Project staff maintained a project reporting system, and prepared bimonthly reports for CNA and quarterly reports for the IBWC. Project staff also maintained financial management, issued contracts to support contractors, and prepared invoices to CNA.

During the summer, project staff prepared a draft year 2000 CNA-NWS agreement and Project Implementation Plan (PIP) and presented it to the PROMMA office for discussion. In September, at the request of SGT, senior CNA and NWS staff met to discuss additions to the draft plan to include methods to strengthen the exchange of hydrometeorological data and information in the Mexico-US border area. Both sides agreed that severe weather systems during the recent hurricane season had highlighted the need for more effective and timely data and information exchange about precipitation and flooding in the border area. Both organizations agreed to automate the exchange of data and information between selected Mexican and US sources of data, exchange visits of key personnel, and preparation of contingency plans, so that both sides are better prepared to assist each other in times of emergency. As a result of the meeting, the NWS Director sent a letter to the SGT Director, which documented an agreement to strengthen trans-border data and information exchange.

Project staff met frequently throughout the year with WMO staff to discuss redesign of data networks, automation of data-collection systems, river forecasting, and information systems. As a result, CNA, WMO, and the NWS agreed to especially coordinate information management systems that are under development by NWS and WMO, and prepare an agreement early in 2000 that will minimize any duplication of effort.

In June, the NWS shipped a recently purchased workstation, known as the Azteca workstation, to Mexico City, which was delivered to GASIR at the end of July. NWS representatives then visited Mexico City, set up the workstation, and conducted systems administration tasks on the all of workstations at the GASIR office at Av. Observatorio 192. During the visit, which continued into August, NWS representatives also prepared the IMTA workstation for transfer to Cuernavaca and Yaqui workstation for transfer to Hermosillo.

Also in the fall, the Yaqui workstation was transferred to Hermosillo and NWS representatives visited Hermosillo in early December to administer the workstation, and integrate it on an IP network with a personal computer that has limited dial-up Internet access. During this installation, the Río Fuerte and Río Yaqui SPRCNA's also were loaded onto the Yaqui workstation.

Task 99.6 Satellite Precipitation Estimation

During the year, the project coordinated the execution of a summer test of precipitation estimation using satellite data in the Río Fuerte and Río Yaqui basins. Satellite-estimated MAP's in 24 sub-basins were compared with MAP's estimated from gage data in the Río Fuerte and Río Yaqui forecast systems. To support the test, the NWS selected a standard grid for computing and displaying all precipitation data in Mexico, including data from radars, rain gages, and satellites. This grid is the Hydrologic Rainfall Analysis Project (HRAP) grid, which is the standard computational grid for precipitation data in the United States.

Project meteorologist Dr. Michael Fortune collaborated with Ing. Jorge Sanchez-Sesma of IMTA to receive hourly estimates of precipitation from IMTA during the period of 1 July - 17 September 1999, which is the season of rainfall in northwest Mexico. The products of his technique, which is called Estimación de Precipitación Pluvial en México (EPPrepMex), became available in real time on the Internet[3] in 1999. In preparation for the test, Ing. Sanchez-Sesma visited Washington in May to meet with colleagues in the NWS, the University of Maryland, NASA, and the National Environmental Satellite, Data, and Information Service (NESDIS). Ing. Sánchez-Sesma presented a seminar on the EPPrepMex satellite technique, which the NWS adopted as a primary source of satellite precipitation in the summer test. In June, Dr. Fortune visited SMN and PROMMA in Mexico City to coordinate preparations for the summer test, and participated in a four-day course on the EPPrepMex technique at IMTA in Jiutepec, Morelos.

Dr. Fortune and Ing. Sánchez-Sesma met with several developers of satellite precipitation algorithms to coordinate participation in the summer test. They met with Dr. Rod Scofield, who was the first scientist to use satellite data for monitoring floods and intense rainfall, and Dr. Gilberto Vicente, the developer of the NOAA "Auto-Estimator" satellite technique. They also met with Dr. Andrew Negri at the NASA Goddard Space Flight Center, who authored the Convective-Stratiform technique for estimation of rainfall; and Dr. Mamadou Ba of the University of Maryland, co-author of the NOAA Multi-Spectral technique.

The summer test was conducted from July 1 through September 16. Throughout the test, project staff collected and stored images and products from four techniques that deliver GOES satellite-based estimates of precipitation. The products of Dr. Negri's NASA technique had to be discarded at the end of the summer due to an error in Negri's computational algorithm. Therefore, three techniques were used: the EPPrepMex technique of IMTA, the NOAA-NESDIS

[3] See at http://nimbus.imta.mx/

AutoEstimator, and the NOAA-NESDIS Multi-Spectral technique.

The NWS completed a hydrological simulation of the Río Fuerte and Río Yaqui basins for the entire test period, using MAP's computed from the conventional rain gage observations. This simulation uses the SPRCNA operated by GASIR as well as the SHEF-encoded observations collected by GASIR. This simulation was compared to parallel simulations that were based on MAP's computed from each satellite technique. Dr. Fortune presented current findings of the Summer Test in American Meteorological Society's annual meeting in Long Beach, CA (Fortune, M and Tokar, A.S., 2000).

The initial results of the summer test concern the following categories.

a. Basin average precipitation.
   - The Multi-Spectral (MS) technique consistently estimated the lowest area-average rainfall amounts.
   - Preliminary results suggest that the MultiSpectral technique has the lowest overall bias of the three satellite techniques.
   - Since the bias of the MS is smaller in general, it may be easy to correct its error by employing an hourly observation from a calibrated rain gage (for example, from an automatic DCP equipped climate station). Such a bias correction procedure is an important task to be done in the year 2000.
   - However, base on the point comparison, the Multi-Spectral technique does not manifest the highest correlations between gage and satellite estimates of precipitation. Both the EPPrepMex and the Auto Estimator have manifested higher correlations. At this time, it is not known which satellite technique will manifest the best correlation with ground truth in the summer of 1999, because more analysis remains to be done.
   - The hourly data from the DCP-equipped climate stations have not been compared yet with satellite estimates. When this analysis is complete, it is expected to provide a basis for selecting one technique as superior in Mexico.
   - A new calibration of the EPPrepMex technique was finished in December 1999. It used data collected in the rainy season of 1998 plus July 1999. The bias of the EPPrepMex technique is now apparently 30 percent to 40 percent lower in the Río Fuerte basin, and 50 percent lower in the Río Yaqui basin, than the bias of the estimates made with the former calibration.
   - Comparison with a gage-based MAP is difficult because the observation periods are so different. The satellite estimates are computed every hour, while the rain gage observations are daily. Information is lost by combining six one-hour satellite estimates into a 6-hour estimate and comparing it with one daily estimate from the rain gage that is distributed uniformly into 6-hour intervals.

b. Streamflow forecasts.

   - Simulations of streamflow in all sub-basins of the Río Fuerte the Río Yaqui were run for the period from 1 July to 25 July 1999, using satellite estimates of mean areal

precipitation. Only, on three sub basins for the Río Fuerte and Yaqui SPRCNAs, streamflow simulations obtained using satellite estimated precipitation were compared to the simulations obtained using gage precipitation for the period extending from July 1 to July 12. Figure 5 shows the results of one simulation of streamflow at San Ignacio in the Río Fuerte based on on gage-based and satellite-based MAP's. Based on the results from simulations for three sub basins, following observations were made:

1. As illustrated on Figure 5, satellite MAPs exhibited peaks in precipitation amounts in 6-hour intervals where as gage precipitation was observed in 24-hour period and uniformly distributed over 6-hour intervals. Consequently, satellite driven hydrographs demonstrated quick increases in streamflow

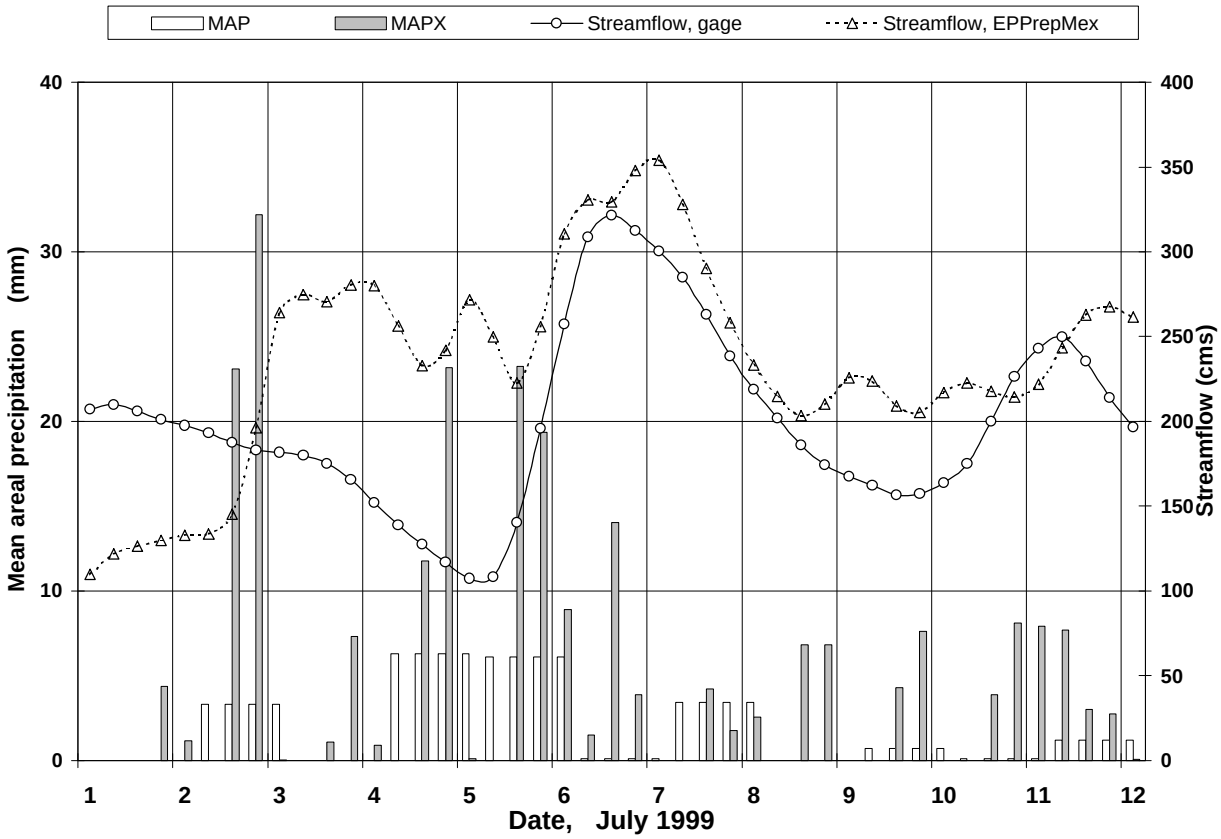


Figure 5. Comparison of simulated streamflow and mean areal precipitation. MAP and MAPX, are mean areal precipitation computed from gage observations and grided satellite estimates, respectively. Gage, and EPPreMex are simulated streamflow based on MAP and EppreMex MAPX, respectively.

where as gage driven hydrographs exhibited a slower response.

2. Some of the rain events that were observed in the satellite MAPs were not observed in the gage data. Therefore, the satellite-based hydrographs registered a peak in the streamflow that was missing in the gage-driven

hydrographs (see Figure 5).

3. The volume of simulated flow tended to be greater in magnitude in the satellite simulations than in gage-based simulations, over periods of a week or longer. This may result from a positive bias in the satellite precipitation data, or temporal variation in precipitation distribution over 24-hour period in satellite estimates.

The hydrologic simulations will continue in 2000. The simulation of streamflow in both the Yaqui and Fuerte watersheds for all 77 days of the summer rainy season will soon be completed. Furthermore, the simulations will be based on three distinct satellite techniques, not just one, in order to determine the bias characteristics of these techniques. In addition, the effect of using 6-hour observations versus 24-hour observations on the streamflow forecasts will be investigated using satellite precipitation estimates.

Knowledge of the expected behavior of satellite precipitation estimates, and streamflow forecasts based on them, will enable a real-time bias correction procedure to be implemented in 2000. Such knowledge will strengthen forecast systems in the Río Fuerte, Yaqui, Pánuco, and Bravo.

99.7 NWSRFS Documentation Translation

In 1998, the NWS competed a document translation contract, which was awarded to Pro International, Inc. (PII) of Minneapolis, Minnesota. In 1998, PII translated approximately 1,100 pages of NWSRFS documentation and in 1999 translated approximately 800 additional pages of documentation.

GASIR's translation team, Ings César Guerrero Ortega, Adriel González Hernández, José Dominguez Esquivel, and Jesús Gutierrez Moreno, reviewed the translated documents throughout the year and worked closely with PII"s technical reviewers. The NWSRFS is a collection of software procedures that perform a variety of hydrologic, hydraulic, and data base management operations and PII employs technical reviewers to quality assure document translation. The technical reviewers are Dr. Sergio De Los Cobos of the Computer Science and Mathematics Department, and Prof. Eugenio Gómez Méndez, and Prof. Gerardo Sánchez of the Civil Engineering department of the Universidad Autónoma Metropolitana (UAM). The technical reviewers helped to assure that the translated documents are consistent with the terminology used in CNA and Mexico.

In early December, Ms. Edith Velosa, President of PII, and technical reviewers met with the GASIR translation team in Mexico City to review a master Spanish-English glossary and documents under translation. PII will provide an updated Glossary to NWS and GASIR after including GASIR's comments. The NWS then will post the Glossary on the NWS web page. NWSRFS documents that have been translated can be found on the Internet[4].

[4] See http://hsp.nws.noaa.gov/oh/tt/DOCS/ESPrfsdoc/users_manual/htm/spxrfsdocwpd.htm

**1999 Budget**

PROMMA reimburses the NWS for its participation in this technology transfer project, but most of the activities in support of this project were undertaken by qualified consultants and consulting firms because the NWS operates under restricted personnel ceilings. Although these consultants acted for the NWS in meetings with CNA counterparts throughout 1999, Curtis Barrett the NWS project manager maintained responsibility for managing the project, assuring that project goals are met, and documenting the project.

In 1998, the NOAA billed CNA for $1,624,058 in U.S. dollars, for tasks that were undertaken in support of this project. Approximate project expenses in 1996 through 1999 are found in Table 1. These expenses are estimated from the NOAA financial management system, which documents obligations and expenditures by US Government fiscal year (October through September), which begins and ends three months earlier than Mexican Government's fiscal year (January through December). Project expenses largely were dedicated to NWS salary and overhead costs, travel, procurement of managerial and technical consultant services, and computer hardware and software. Table 2. lists the hardware and software systems that have been procured by the project since 1996, serial numbers of major hardware components, their locations, serial numbers, and costs. Their serial numbers and final costs are not yet available. The NWS maintains responsibility for all systems that reside at NWS and contractor facilities in the US, and will assure that all of these items are provided to the CNA prior to the conclusion of the project. The cost of maintenance contracts on the workstations in the US are included by the NWS in the hardware and software costs of Table 1.

Table 1. NWS project costs, 1996-1999 (approximate)

| | | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| NWS Employee Costs | | | $144,000 | $144,000 | $70,000 |
| Travel | | | $66,000 | $50,000 | $51,000 |
| Consulting services | | | | | |
| | Management and Administrative | $61,500 | $101,000 | $278,000 | $274,000 |
| | Technical | | $348,000 | $961,000 | $1,066,000 |
| Computer Hardware and Software | | $138,500 | $126,000 | $22,000 | $163,000 |
| Total | | $200,000 | $785,000 | $1,455,000 | $1,624,000 |

Table 2. Locations, serial numbers, and costs[5] of hardware, software, and other procured by the CNA-NWS project, 1996-1999.

NOT AVAILABLE

[5]Table 2 does not include four workstations, data bases, and associated software and hardware, which were procured late in the year and for which final costs and serial numbers are unavailable.

**Recomendaciones del Proyecto**

Las siguientes recomendaciones intentan reforzar el progreso que se ha hecho en este proyecto. Las recomendaciones tienen que ver con la coordinación del programa, desarrollo técnico y entrenamiento.

Coordinación del Programa-El NWS recomienda que:

- CNA, NWS y la OMM refuercen la coordinación de sus actividades, especialmente las concernientes a sistemas de información, para evitar duplicación de esfuerzos,
- NWS revea los diseños de las redes de recolección de datos del OMM para cuencas donde se implementará la tecnología NWSRFS,
- NWS asista a CNA y a CILA a determinar los productos de datos y pronóstico del Río Bravo que CILA requiere para cumplir con sus requisitos operacionales,
- La CNA de las Regiones de Península Baja de California, Noroeste y Río Bravo designe puntos de contacto técnicos para intercambio de datos e información con su contrapartida en los estados americanos fronterizos, y que el NWS identifique puntos de contacto para el lado americano.

Desarrollo Técnico y entrenamiento- El NWS recomienda que:

- GASIR y CNA adquieran equipos de computación (hardware) y programas (software) para sus estaciones de trabajo de Hewlett-Packard (HP),
- GASIR designe un punto de contacto técnico para facilitar el uso del FLDWAV en el Río Pánuco,
- GASIR designe un punto de contacto técnico para facilitar el desarrollo de los sistemas de manejo de emergencias basados en GIS para Tampico, y lleve a cabo entrenamiento y desarrollo cooperativo en los EE.UU,
- GSMN designe puntos de contacto técnicos para la estimación de precipitaciones de satélite y radar en 2000,
- El plan de entrenamiento de plantel de 2000 para el personal que ya ha recibido entrenamiento sobre NWSRFS, debe enfocarse en entrenamiento práctico sobre las tareas de los proyectos, que ha de reforzar la capacidad de CNA en la implementación y operación de sistemas de pronóstico, como así también acelerar el paso del despliegue de dicho sistema,
    - GASIR contrate o entrene un administrador de base de datos relacionales para apoyar el IG-DB. En 2000, el IG-DB tendrá el potencial de apoyar sistemas de datos y de pronósticos regionales y nacionales en operación, y la administración de datos será crítica para un aprovechamiento exitoso.

**Recommendations**

The following recommendations are intended to strengthen the progress that has been made on this project. The recommendations concern program coordination, and technical development and training.

Program Coordination—The NWS recommends that:

- CNA, NWS, and WMO strengthen coordination of their activities, especially with regard to information systems, so that there is no duplication of effort,
- NWS reviews WMO data-collection network designs for basins where NWSRFS technology will be implemented,
- NWS assists CNA and CILA determine the Río Bravo forecast and data products that CILA requires to meet its operational requirements, and
- CNA Peninsula de Baja California, Noroeste, and Río Bravo Regions designate technical points of contact for data and information exchange with counterparts in United States border States, and that the NWS identify points of contact for the US side.

Technical development and training—The NWS recommends that:

- GASIR and CNA purchase hardware and software support for their Hewlett-Packard (HP) workstations,
- GASIR designates a technical point of contact to facilitate use of FLDWAV in the Río Pánuco,
- GASIR designates a technical point of contact to facilitate development of GIS-based emergency management systems for Tampico and undertake training and cooperative development in the United States,
- GSMN designates technical points of contact for satellite and radar precipitation estimation in 2000.
- The 2000 staff training plan for staff who have received NWSRFS training should focus on practical training on project assignments, which will strengthen CNA capability in forecast system operation and implementation, and accelerate the pace of forecast system deployment, and
- GASIR hire or train a relational database administrator to support the IG-DB. In 2000, the IG-DB will have the potential to support an operational national and regional forecast and data systems, and database administration will be critical to its success.

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**Acronyms**

The following acronyms appear in this report.

| | |
|---|---|
| CILA | Comisión Internacional de Límites y Aguas |
| CNA | Comisión Nacional del Agua |
| DCP | Data Collection Platform |
| DEM | Digital Elevation Model |
| EPPrepMex | Estimación de Precipitación Pluvial en México |
| FLDWAV | Flood Wave (hydraulic model) |
| GASIR | Gerencia de Aguas Superficiales e Ingeneria de Ríos |
| GIS | Geographic Information System |
| GOES | Geostationary Operational Environmental Satellite |
| GSMN | Gerencia de Servicio Meteorologico Nacional |
| HIF | Hydrologic Instrumentation Facility |
| HRAP | Hydrologic Rainfall Analysis Project |
| HP | Hewlett Packard |
| IBWC | International Boundary and Water Commission |
| IG-DB | Integrated GASIR Data Base |
| IP | Internet Protocol |
| IMTA | Instituto Mexicano de Technología del Agua |
| MAP | Mean Areal Precipitation |
| NASA | National Aeronautics and Space Administration |
| NESDIS | National Environmental Satellite, Data, and Information Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NOHRSC | National Operational Hydrologic Remote Sensing Center |
| NWRFC | Noroeste River Forecast Center |
| NWS | National Weather Service |
| NWSRFS | National Weather Service River Forecast System |
| PII | Pro International, Inc. |
| PIP | Project Implementation Plan |
| PROMMA | Programa de Modernización del Manejo del Agua |
| RBRFC | Río Bravo River Forecast Center |
| RFC | River Forecast Center |
| RRFC | Regional River Forecast Center |
| RTi | Riverside Technology inc. |
| SGT | Subdirección General Téchnico |
| SHEF | Standard Hydrologic Exchange Format |
| SIGA | Sistema Geográfico de Información del Agua |
| SPRCNA | Sistema de Pronóstico en Ríos de la CNA |
| UAM | Universidad Autónoma Metropolitana |
| USGS | U.S. Geological Survey |
| WGRFC | West Gulf River Forecast Center |
| WMO | World Meteorological Organization |